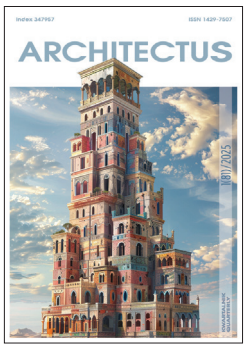

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Systematics of AI tools supporting creative problem-solving and inventive methods in architectural design

Abstract

The dynamic development of AI tools significantly influences contemporary design processes, including architectural design. These tools open new perspectives for creators, supporting them at various stages of their work. AI is becoming a key element in assisting designers in architecture. However, there is still a lack of a systematic approach and classification of these tools regarding creative problem-solving, inventive methods, and intuitive and metaphorical thinking.

This article aims to analyse the potential use of available AI tools to support inventive methods in the creative problem-solving process. The first objective is to systematize AI tools with potential applications within inventive methods. The second objective is to identify ways of utilization at different stages of the creative process.

The analysis is based on data gathered through desk research and the classification according to criteria of popularity and functionality. Tools were grouped into five application areas, relating them to the stages of the creative process.

The research applied literature analysis, observation, deduction, and synthesis methods. Additionally, the research process was based on inventive methods: finding connections, alignment between theories, example excursions, mind mapping, deduction and intuitive method that served as the impulse for conceptual actions at each research stage.

The result is an open systematization of AI tools, enabling designers to compare and select tools that best suit their preferences. The classification, according to application areas, allows for the selection of a tool based on the nature of the inventive methods used and the stage of the creative problem-solving process. The developed tabular summaries facilitate a straightforward identification of tools appropriate for specific tasks. The research findings highlight the need for further verification of the practical application of AI tools and their incorporation into architectural education, which will enable a fuller utilization of the potential of these technologies in the design process.

Key words: architectural design, AI tools, inventive methods, creative problem-solving process

Introduction

Society faces a technological revolution, with artificial intelligence (AI) being the primary catalyst for this change. The introduction of new technologies not only opens the door to innovation but also raises questions about their impact on society and ethics. At the same time, due to the rapid pace of technological advancement, the constant challenge remains functioning in an ever-changing environment, where these technologies reshape social values and establish new ethical standards, creating threats such as discrimination or privacy violations (Ortega-Bolaños et al. 2024). Therefore, it is crucial to understand how AI influences various aspects of our activities and what measures can be taken to minimize these potential risks. Equally important is considering user comfort when utilizing AI tools and understanding their potential concerns regarding implementing new systems (Nigam et al. 2021).

In the context of the mentioned challenges, AI is also revolutionizing the architectural design process by enhancing efficiency, promoting sustainable development, and fostering creativity (Almaz et al. 2024). AI applications in architecture include generative design algorithms, virtual reality tools, and machine learning, enabling architects to explore innovative design solutions and optimize projects for energy efficiency (Almaz et al. 2024; Chaillou 2021).

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Integrating AI with Building Information Modeling (BIM) allows for real-time analysis and optimization, saving time and resources (Almaz et al. 2024). The role of AI in architecture has evolved – from early experiments with computer-aided design to contemporary applications in generative design and construction robotics (Tellios, Koulali and Valsamidou 2023). Although AI provides unprecedented resources for design inspiration and parametric exploration, it is crucial to maintain a sustainable approach to ensure that AI-generated designs are human-centred, ecologically responsible, and culturally sensitive (Hegazy, Saleh 2023). Integrating AI in architectural education is also recommended, as it can help designers better understand key concepts related to the design process (Almaz et al. 2024).

Modern technologies, including AI-powered tools, undoubtedly open new perspectives in the design process – including the search for architectural forms. However, their implementation should be carried out while preserving elements known from previous design practices. The key assumption is that these tools should not replace human creativity but rather complement it, supporting architects in creative processes and enriching their potential (Jaruga-Rozdolska 2022).

The creative thinking process is inherently exploratory, characterized by variability, dynamism, complexity, and unpredictability – moreover, it requires an active stance from the subject (Proctor 2002, 12). At the same time, a far more comfortable state is the attachment to an established and familiar paradigm of action based on previously developed solutions and experiences – which often limits the ability to discover innovative solutions (Proctor 2002, 29–33).

One of the strategies for designing architectural form can be the creative problem-solving process (Adamiczka 2022), which is based on the equal participation of two types of thinking: reproductive (rational) and productive (creative intuition). Reproductive thinking utilizes knowledge and experience, focusing on the analysis and identification of key aspects of the problem (Proctor 2002, 40, 41); productive thinking, on the other hand, is based on ignorance – spontaneous and disordered abstractions, verbal associations, often expressed in the form of images or emotions, which allows for the generation of new ideas (Proctor 2002, 29–33). The tools that enable the change of the existing paradigm and the introduction of new solutions are inventive methods (Kwiatkowska 2007, 278–283). The combination of these two types of thinking leads to creativity (Fig. 1).

The aforementioned dynamic development of technology, including AI, and the tremendous rise in the popularity of tools based on it are significantly changing the possibilities in the design process. As a result, incorporating AI as one of the potential tools in the creative process is not only an opportunity but an absolute necessity – especially when considering the key factor that conditions this process: […] *the selection of a technique in which the designer feels confident – one that will not limit them* (Adamiczka 2022, 111). Thinking about contemporary and future generations utilizing increasingly accessible technologies, it is clear that the integration of AI-based tools with inventive methods is, thus, a natural step, enabling the exploration of new ways of solving design problems.

The main issue addressed in this article is the potential use of widely available AI-based tools as instruments to support inventive methods in the process of creative problem-solving. The first aim of the discussion is to systematize available, commonly used AI tools and their potential applications in the context of inventive methods. The second aim is to identify the possibilities of utilizing AI tools in the various steps of this process.

Considering the lack of a clearly defined set of widely available AI tools in the literature, realizing the first goal and creating a systematized list of tools in the context of architecture help raise designers' awareness of the available opportunities for their use. Due to the dynamic development and technological changes, the list should be treated as open and an incentive for further exploration by those interested in the topic. The research adopted two limitations: 1) the compilation does not serve as a guide for using individual tools or evaluating their effectiveness; 2) the author focused solely on the process of creative problem-solving, treated as a path within the previously described architectural design strategy model[1]. The analysis addresses the methodology of the process and the supporting tools, leaving the issue of the architectural form itself beyond the scope of the discussion. This perspective about achieving the second research goal allows for a focus on the universal aspects of the process, which can be applied in various design contexts and serve as a stimulus for the creative search for problem-solving solutions.

State of research

The topic of AI is currently experiencing exceptional popularity within specialist circles and a wider audience. This is not only due to the development of technology itself but also its growing impact on daily life and various professional activities[2]. The rapid pace of development in

[1] The indicated model of the architectural design strategy, based on the creative problem-solving process, was described in 2022 in the doctoral dissertation titled: "The Process of Creative Problem Solving as a Strategy for Designing an Architectural Form in the Context of the Phenomenon of Perception" (Adamiczka 2022; in Polish).

[2] The scale and pace of the aforementioned development can be indicated by the total funding raised by the 50 largest companies in the AI sector since 2020, which reached $52.8 billion by 2024. Particularly notable was 2023, when a 600% increase was recorded compared to 2020 (Sarkar 2024). This reflects one of the key aspects of this technological transformation: the widespread availability of AI-based tools to a broad audience, which contributed to their unprecedented popularity. Between September 2022 and August 2023, over 24 billion visits were recorded on the 50 most popular AI tool websites (Sarkar 2023). A prime example is ChatGPT, which has gained tremendous recognition since its debut in November 2022 and has become one of the fastest-growing AI-based solutions. Within the first five days of its launch, the tool had 1 million users, and by January 2024, this number grew to over 100 million active monthly users. After another nine months, by November 2024, ChatGPT recorded around 200 million active weekly users (compared to 100 million active weekly users in November 2023). The tool's popularity was also evident in the number of website visits, which peaked at 1.8 billion monthly. The tool's success was also reflected in the mobile space – the ChatGPT app for iOS and Android was downloaded over 100 million times, underscoring its widespread usage (Singh 2024; Brandl, Cai 2024).

this field and its broad influence on many areas of life and professional activities have contributed to the increased interest in both the practical use of AI and its theoretical aspects. This phenomenon is reflected in the vast number of publications in recent years, which focus not only on the technological development of AI-based specialized tools but also on analysing the ethical and social consequences of their use, as well as their presence and application in education. In 2024 alone, Google Scholar's database contains approximately 23,900 records related to the term "AI-based tools in education"[3].

Similarly, in the field of architecture, there is an increasing influence of AI tools, which are widely used both in generating design concepts and in automating design processes. The application of AI in design opens new perspectives but also raises questions about the role of the architect in the future and the boundaries between creativity and automation (As, Pal and Basu 2018). Deep learning-based approaches allow for analysing existing designs, identifying their key elements, and creating new compositions (As, Pal and Basu 2018). AI is applied at various stages of the design and implementation process, which opens up opportunities for automating many aspects of an architect's work (Mrosla, Koch and Both 2019). Implementing AI in architecture influences not only the design processes and proposed solutions but also redefines the architect's role in future professional practice (Said et al. 2023).

As mentioned, the topic of AI-based tools discussed in the literature typically focuses on specialized tools and their technical aspects. In architecture, the development of technology is also concentrated on attempts to create tools capable of solving complex design problems. An example is a machine learning system based on graphs operating in three-dimensional space, where the authors highlight the greater complexity both in terms of structure and combinatorics compared to systems operating with images, text, or voice (As, Pal and Basu 2018).

In the context of considerations regarding AI as a tool supporting inventive methods, it is essential to address aspects of accessibility and inclusivity. The systematized tools should not only be available to a wide range of users but also be simple to operate and free from technological limitations that could hinder the creative thinking process. The manner of their use should leave room for intuition – both to counteract the most destructive beliefs that block creativity (Proctor 2002, 46) and, as previously mentioned, the dual nature of thinking in the design process – based on creative intuition (ignorance and imagination) and rational thinking (knowledge and understanding) (Kwiatkowska 2018, 97–99), as well as for potentially achieving the most excellent effectiveness of actions (Tarczewski 2019, 49). Considering that the source of creative intuition is metaphorical thinking (Kwiatkowska 2018, 97–99), an important role of these tools is to stimulate and inspire the designer by providing new perspectives, stimuli, and inspiration. According to the principles of the creative problem-solving process, the methods and tools used within it should support creativity by offering new possibilities and facilitating the realization of the designer's intentions rather than replacing their role. Their main goal is to assist in various stages of the design process while maintaining the key element of human intuition and experience in the decision-making process (Adamiczka 2022).

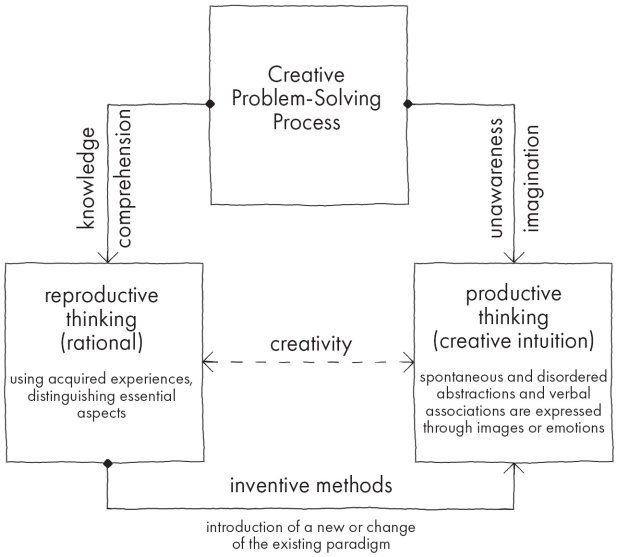

Fig. 1. The relationship between rational thinking and creative intuition in the creative thinking process (elaborated by B. Adamiczka based on Proctor 2002, 29–33, 40, 41; Kwiatkowska 2007, 278–283)

Il. 1. Relacja myślenia racjonalnego i twórczej intuicji w procesie twórczego myślenia (oprac. B. Adamiczka na podstawie: Proctor 2002, 29–33, 40, 41; Kwiatkowska 2007, 278–283)

Earlier, Hegazy and Saleh, while studying the development of AI in architecture, categorize the use of AI tools into two pathways: parametric exploration and machine hallucination. The first pathway relies on the aforementioned complex tools that consider the detailed parameters input by the designer. In contrast, the second pathway utilizes […] *the ability of a machine or computer program to generate sensory experiences that do not correspond to any real-world input and that are not based on any actual input, but rather are generated entirely by the machine itself* (2023, 12). Regarding the second pathway, the authors further point out significant limitations associated with the use of such tools in the concept creation process, including limited control and customization options, lack of consideration for the feasibility of the structural design, and inconsistency in the results obtained (Hegazy, Saleh 2023).

At the same time, the description of the second pathway corresponds to the previously mentioned metaphorical thinking. However, Hegazy and Saleh, when describing and evaluating the discussed tools, apply criteria based on rational (reproductive) thinking – based on parameters and measurable real-world characteristics. Referring to the previously mentioned role of intuition in creative thinking, the discussion must also be supplemented with the significant role of perception in the entire process. This includes, for

[3] Among them, the following works are referenced (As, Pal and Basu 2018; Mrosla, Koch and Both 2019; Said et al. 2023; Hegazy, Saleh 2023).

instance, the distortion and simplification of complex realities by observers (Lynch 2011, 123), the action of induction and perceptual forces (Arnheim 2013, 21–23), as well as the cognitive stratification of what surrounds us – stemming from aesthetic philosophy theory – distinguishing the physical world, the world of representation, and the world of assumptions about the reality behind these representations (Gage 2017).

In light of the above, it must be stated that there is a lack of sources in the literature that systematically and comprehensively describe the approach combining metaphorical and rational thinking in the context of evaluating AI-based tools. At the same time, such an application of AI tools[4] was investigated and described in his doctoral dissertation Tomasz Broma within the test method of operational transformation of archetypal shapes, comparing the results of using the inventive method in both traditional and AI-assisted ways (2023, 221–224)[5]. However, other available studies, including those referenced in this paper, focus on analysing AI tools' technical parameters and measurable characteristics, neglecting the key role of intuition, perception, and the subjective reception of reality by users – factors that play a significant role in the creative process. This gap highlights the need to supplement existing research with a perspective that includes intuitive action, which could expand the application potential of AI tools in design practice based on inventive methods.

Furthermore, applying the previously discussed limitation of considering AI tools to those that are widely available and intuitive to use, it should be noted that there is a lack in the literature of a comprehensive, systematic compilation of such tools and their relation to the issue of the creative problem-solving process.

Methods

The presented research was conducted between September 2022[6] and October 2024. Key activities were carried out in the third and fourth quarters of 2024. The study aimed to create an organized collection of AI tools and identify their potential applications in the creative problem-solving process. Below, the subsequent steps of the study are described, considering their sequence and main assumptions.

At the same time, before proceeding with a detailed description of the method, it is important to emphasize that the systematization of AI tools is not only an academic goal but also a practical support for designers and researchers.

Stage 1: Selection of AI tools

As mentioned, the categorized tools should not only be accessible to a wide range of users but also be easy to use and free from technological constraints that could hinder the creative thinking process. The primary factor influencing the choice of a tool was the assumption that it should support the designer, allowing creative freedom through intuitiveness and ease of use.

In light of the above, the AI tools considered were limited to the most popular and widely accessible ones based on the criterion of website traffic data for the tools. In this regard, data from an analysis conducted by Sujan Sarkar was used. Using SEMrush, he analysed information about over 3,000 AI tools gathered from various directories. Based on this, he identified the 50 most visited tools, which together accounted for over 80% of the AI industry's traffic between September 2022 and August 2023 (Sarkar 2023). The identified 50 AI tools were adopted as the foundation for the subsequent steps (Table 1, column R), focusing primarily on AI-based solutions and excluding tools that utilize AI elements as part of specific functions and serve only as supplements to a broader range of tools.

Stage 2. Characterization of selected AI tools

In the next step, a characterization of the selected tools was developed using the desk research method, which included the analysis of relevant literature, technical documentation, APIs, and press materials, including industry articles and technological reviews. The characterization was prepared in tabular form. Based on the aforementioned data, the following aspects were included: tool category, popularity (total number of visits from 09.2022 to 08.2023), and website address (Table 1, columns C, D, R) (Sarkar 2023). At the same time, taking into account the decision-making process in the design phase regarding the selection of an AI tool, additional aspects directly related to the use of the tool were added: main applications, scope of application, input data type (basic), input data type (additional), output data type, user control, languages, hardware requirements, integration with other tools, pricing model and license, privacy management, and training materials (Table 1, columns E, F, G, H, I, J, K, L, M, N, O, P). These aspects were then defined and assigned a specific set of values, allowing for precise classification and analysis (Table 1, legend I).

Stage 3: Organizing the AI tools set by application areas

The list of tools was organized by grouping them based on their purpose, i.e., tool category and main application (Table 1, columns C, E). Then, five application areas were abstracted (Table 1, legend II, column B). The names of the areas are characterized by the simplicity that is so important in the creative thinking process while simultaneously reflecting the basic medium used by the tools. Within each group, the tools were organized according to the previously mentioned hierarchy of popularity (Table 1, column D)

[4] The result of the tool's operation serves as an inspiration, a representation of the abstract understanding of the operation, and a means to break through initial constraints (Broma 2023, 221–224) for further design actions – rather than providing a ready-made solution to the design problem.

[5] Although this case is an exception in the literature, it pertains to a specific application of a selected and described tool (procedure) and does not address the systematic classification of AI tools.

[6] This is due to the availability and widespread adoption of the ChatGPT tool, which has significantly contributed to the popularization of AI technology and increased access to information about it (Singh 2024; Brandl, Cai 2024).

and characterized, including a brief description, main applications, and examples of AI tools for each application area (Table 1, legend II, columns C, D, E, F). Subsequently, the specific possibilities for each group to serve as tools supporting the use of inventive methods were indicated (Table 1, legend II, column G).

Stage 4: Identification of potential uses

After identifying and describing the areas of application of AI tools, based on their distinctive capabilities (Table 1, legend II, column G), the potential uses of these tools within the successive steps of the creative problem-solving process were compiled.

For this purpose, the author's model of the creative problem-solving process pathway, used as a strategy for designing an architectural form in the context of its perception (Fig. 2), was employed. This model aims to stimulate creative thinking, define problems, and seek creative solutions regarding architectural form. The developed pathway aligns with the assumptions of creative problem-solving theory. It guides the designer through all stages of the process – beginning with problem identification, continuing through the entire design process, and concluding with the final version of the project and its verification in terms of achieving the goal (Adamiczka 2022). Thus, for each step of the pathway (Table 2, columns A, B) and each area of application (Table 2, column C), the possibilities for utilizing these tools were identified (Table 2, column D).

Research approach

The above process (stages 1–4) was carried out using an interactive research and analytical process with the help of a language model based on artificial intelligence to assist in data analysis, classification, and description of AI tools, using the ChatGPT-4 tool to support exploration and systematization within the process. The virtual transcript, totalling approximately 7300 lines[7], includes preliminary instructions, a summary of the conversations, as well as methodological limitations and research uncertainty, which was collectively estimated at 10–20%. At the same time, the conversations were conducted in prototype mode, including side and incomplete conversations with the language model[8]. Most importantly, the transcript includes data and assumption verification using scientific methods such as synthetic, analytical, deductive, inductive, observation, and literature analysis. Additionally, the considerations during the process were based on the following methods rooted in inventive methods: analysis method, relationship-finding method, congruence between theories method, example excursion method, mind mapping method, and deduction method – preceded by an intuitive method, which served as the stimulus for the actions taken in the conceptual phase of each stage of the considerations.

Results

The result of the conducted research process is a collection of tables that together form an open tool supporting the designer in terms of the potential use of AI tools – both in the context of their identification, initial exploration, and selection. Ultimately, with the collected data, it is possible to make an informed approach to selecting the appropriate tools based on their functionality and application. Three areas have been identified in which the results of the work can provide support to the creator:

1. Identification of the preferred AI tool – the created tabular compilation of the most popular, widely available, and intuitive AI tools, along with their parameterized characterization and classification by application areas – provides the ability to consciously choose a tool that meets the creator's needs and preferences (Table 1).

2. Identification of the preferred application area of AI tools based on the type or nature of the employed inventive method – a tabular compilation of the designated application areas, representing groups of AI tools, by indicating the characteristic possibilities of their use during the application of inventive methods (Table 1, legend II) – provides the ability for the creator to make a selection based on the nature of the inventive method used.

3. Identification of the preferred application area of AI tools based on the stage of the creative problem-solving process – a tabular compilation of the designated application areas, representing groups of AI tools, by relating them to the creative problem-solving process model along with indicating their application possibilities (Table 2) – allows the creator to make a selection based on the stage of this process.

At the same time, the proposed systematics remains an open tool – using the presented characterizing aspects (Table 1, legend I), the creator can consider using an AI tool outside of the list presented in the paper by comparing and analysing it with those already included.

Conclusions

The study results confirm the possibility of creating a practical taxonomy of widely available AI-based tools. The developed classification of tools represents a significant contribution to design methodology development, enabling more conscious and efficient use of available solutions. A key feature of the created taxonomy is its open nature, allowing for continuous adaptation to the dynamic development of AI.

By precisely parameterizing the aspects characterizing these tools, a comprehensive comparison is made possible, allowing for an assessment of their functionality in relation to various aspects of the creative process and the creator's preferences. The tabular form of the summaries facilitates quick and straightforward comparisons of available solutions, supporting the decision-making process in selecting the tool best suited to current design needs. As a result, this

[7] The corresponding number of 438,000–584,000 characters with spaces.

[8] Due to the imperfections (such as suspension and loss of data from conversations) and the continuous development of the tool (the availability of a new version of the GPT model required starting a new chat every day).

Table 1. Classification of selected AI tools (elaborated by B. Adamiczka)
Tabela1. Klasyfikacja wybranych narzędzi AI (oprac. B. Adamiczka)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
	No.	Tool Name	Category	Popularity (Total Visits bn)	Main Applications	Scope of Application	Input Data Type (Basic)	Input Data Type (Additional)	Output Data Type	User Control	Languages	Hardware Requirements	Integration with other tools	Pricing model and license	Privacy Management	Training Materials	Web Address
Text oriented tools	1	ChatGPT	AI Chatbot	14,6	Conversations and Chatbots, Text Generation	Universal	Text	Image	Text, Image	High	Multilingual	Online	Flexible API	Freemium, Subscription, Pay-as-you-go (Educational)	Stored and Used for AP (with User Control)	Documentation, Video Tutorials, User Community	chat.openai.com
	2	Character AI	AI Chatbot	3,8	Conversations and Chatbots	Specialized	Text	None	Text	Medium	<10	Online	No integration	Free	Stored and Shared	Documentation, User Community	character.ai
	3	Quillbot	AI Writing	1,1	Text Generation	Universal	Text	None	Text	Medium	Multilingual	Online	Compatibility	Freemium, Subscription (Educational)	Stored and Used for AP	Documentation, Video Tutorials	quillbot.com
	4	Google Bard	AI Chatbot	0,2416	Conversations and Chatbots, Text Generation	Universal	Text	Image	Text	Medium	Multilingual	Online	Flexible API	Free	Stored and Shared (with User Control)	Documentation, Video Tutorials	bard.google.com
	5	NovelAI	AI Writing	0,2387	Creative Applications, Text Generation	Specialized	Text	None	Text	High	1 (English)	Online	No integration	Subscription	Stored and Used for AP	Documentation	novelai.net
	6	Janitor AI	AI Chatbot	0,1924	Conversations and Chatbots	Specialized	Text	None	Text	Low	<10	Online	Flexible API	Free	Stored and Shared	User Community	janitorai.com
	7	You.com	AI Chatbot	0,1403	Conversations and Chatbots	Universal	Text	None	Text	Medium	Multilingual	Online	Flexible API	Free	Stored and Used for AP (with User Control)	Documentation, Video Tutorials	you.com
	8	Perplexity AI	AI Chatbot	0,1343	Conversations and Chatbots	Specialized	Text	None	Text	Low	Multilingual	Online	No integration	Free	Stored and Used for AP	Documentation	perplexity.ai
	9	Copy.ai	AI Writing	0,1093	Text Generation	Universal	Text	None	Text	Medium	Multilingual	Online	Compatibility	Freemium, Subscription	Stored and Used for AP	Documentation, Video Tutorials, User Community	copy.ai
	10	Jasper	AI Writing	0,0949	Text Generation	Universal	Text	None	Text	Medium	<50	Online	Flexible API, Compatibility	Subscription	Stored and Used for AP	Documentation, Online Courses	jasper.ai
	11	Writesonic	AI Writing	0,0807	Text Generation	Universal	Text	None	Text	Medium	Multilingual	Online	Flexible API, Compatibility	Freemium, Subscription (Educational)	Stored and Used for AP	Documentation, Video Tutorials, User Community	writesonic.com
	12	CrushOn AI	AI Chatbot	0,0246	Conversations and Chatbots	Specialized	Text	None	Text	Low	1 (English)	Online	No integration	Free	Stored and Shared	User Community	crushon.ai
	13	Claude AI	AI Writing	0,0212	Text Generation	Universal	Text	None	Text	Medium	Multilingual	Online	Flexible API	Free	Stored and Used for AP	Documentation, Video Tutorials	claude.ai
	14	Personal AI	AI Chatbot	0,0179	Conversations and Chatbots	Specialized	Text	None	Text	Low	<10, Adaptable	Online	Flexible API	Freemium, Subscription	Stored and Used for AP (with User Control)	Documentation, User Community	personal.ai
	15	ChatDoc	AI Writing	0,0086	Text Generation	Specialized	Text	None	Text	Medium	Multilingual	Online	No integration	Freemium, Subscription	Stored and Used for AP	Documentation, Video Tutorials	chatdoc.com

A		B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
	No.	Tool Name	Category	Popularity (Total Visits bn)	Main Applications	Scope of Application	Input Data Type (Basic)	Input Data Type (Additional)	Output Data Type	User Control	Languages	Hardware Requirements	Integration with other tools	Pricing model and license	Privacy Management	Training Materials	Web Address
Image oriented tools	16	MidJourney	Image Generator	0,5004	Image and Graphic Generation	Specialized	Text, Image	None	Image	High	1 (English)	Online	No integration	Subscription, Pay-as-you-go (Educational)	Stored and Used for AP	User Community, Interactive Materials	midjourney.com
	17	CivitAI	Image Generator	0,1772	Image and Graphic Generation	Specialized	Image	None	Image	High	1 (English)	Online	Compatibility	Free	Stored and Shared	User Community	civitai.com
	18	Cutout.pro	Background Removal	0,1335	Background Removal and Image Modification	Specialized	Image, Video	None	Image	Medium	<50	Online	Compatibility	Freemium, Subscription	Stored and Shared	Documentation, Video Tutorials	cutout.pro
	19	Craiyon	Image Generator	0,1281	Image and Graphic Generation	Specialized	Text, Image	None	Image	Medium	1 (English)	Online	No integration	Free	Stored and Used for AP	Documentation	craiyon.com
	20	Leonardo AI	Image Generator	0,1016	Image and Graphic Generation	Specialized	Text, Image	None	Image	High	<50	Online / Local+ (limited offline)	Compatibility	Freemium, Subscription	Stored and Used for AP	Documentation, Video Tutorials	leonardo.ai
	21	DeepAI	Image Generator	0,0891	Image and Graphic Generation	Specialized	Text, Image	None	Image	Medium	1 (English)	Online	Flexible API, Compatibility	Free (Open-source)	Stored and Used for AP	Documentation, User Community	deepai.org
	22	Playground AI	Image Generator	0,0793	Image and Graphic Generation	Specialized	Text, Image	None	Image	High	1 (English)	Online	No integration	Free	Stored and Used for AP	Documentation	playground-ai.com
	23	Stable Diffusion Web	Image Generator	0,0851	Image and Graphic Generation	Specialized	Text, Image	None	Image	High	1 (English)	Online / Online+ / Local+ (lim. offline)	Flexible API, Compatibility	Freemium, Pay-as-you-go (Open-source)	Stored and Used for AP	Documentation, User Community	stablediffusionweb.com
	24	Clipdrop	Image Generator	0,0748	Background Removal and Image Modification	Specialized	Image	None	Image	Low	<50	Online	Compatibility	Freemium, Pay-as-you-go	Stored and Shared	Documentation, Interactive Materials	clipdrop.co
	25	Lexica.art	Image Generator	0,0629	Image and Graphic Generation	Specialized	Text, Image	None	Image	Medium	1 (English)	Online	No integration	Free	Stored and Used for AP	Documentation	lexica.art
	26	PixAI	Image Generator	0,0615	Image and Graphic Generation	Specialized	Text, Image	None	Image	High	1 (English)	Online	No integration	Free	Stored and Used for AP	Documentation	pixai.art
	27	OpenArt	Image Generator	0,0509	Image and Graphic Generation	Specialized	Text, Image	None	Image	High	1 (English)	Online	No integration	Free	Stored and Used for AP	Documentation	openart.ai

Table 1 continued. Classification of selected AI tools (elaborated by B. Adamiczka)
Tabela 1 cd. Klasyfikacja wybranych narzędzi AI (oprac. B. Adamiczka)

A		B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
	No.	Tool Name	Category	Popularity (Total Visits bn)	Main Applications	Scope of Application	Input Data Type (Basic)	Input Data Type (Additional)	Output Data Type	User Control	Languages	Hardware Requirements	Integration with other tools	Pricing model and license	Privacy Management	Training Materials	Web Address
Image oriented tools	28	ZMO.AI	Image Generator	0,0496	Image and Graphic Generation	Specialized	Image	None	Image	Medium	<50	Online	No integration	Freemium, Pay-as-you-go	Stored and Shared	Documentation, Interactive Materials	zmo.ai
	29	Remini	Image Editor	0,0494	Background Removal and Image Modification	Specialized	Image	None	Image	Low	<50	Online	No integration	Freemium, Pay-as-you-go	Stored and Shared	Documentation	remini.ai
	30	Dezgo	Image Generator	0,0479	Image and Graphic Generation	Specialized	Text, Image	None	Image	High	1 (English)	Online	No integration	Free	Stored and Used for AP	Documentation	dezgo.com
	31	VanceAI	Image Generator	0,0417	Background Removal and Image Modification	Specialized	Image	None	Image	Medium	<50	Online	Compatibility	Freemium, Subscription	Stored and Shared	Documentation, Video Tutorials	vanceai.com
Video oriented tools	32	CapCut	Video Generator	0,2038	Video and Audio Editing	Specialized	Video	Sound	Video, Image	High	<50	Local (online)	Compatibility	Freemium, Subscription	Stored and Shared	Video Tutorials, Interactive Materials	capcut.com
	33	Runway ML	Video Generator	0,073	Video and Audio Editing	Specialized	Video	Image	Video	High	1 (English)	Local (online) / Local+ (lim. offline)	Flexible API, Compatibility	Freemium, Subscription	Stored and Used for AP	Documentation, Video Tutorials, User Community	runwayml.com
	34	D-ID	Video Generator	0,0673	Video and Audio Editing, Creative Applications	Specialized	Video, Sound	Image	Video, Sound	High	<50	Online	Flexible API	Subscription	Stored and Shared	Documentation, Video Tutorials	d-id.com
	35	Synthesia	Video Generator	0,0582	Video and Audio Editing, Teaching and Education	Specialized	Video, Sound	Text	Video	High	Multilingual	Online	Flexible API	Subscription (Educational)	Stored and Used for AP	Documentation, Online Courses, Interactive Materials	synthesia.io
	36	Kaiber	Image & Video Generator	0,0476	Video and Audio Editing, Image and Graphic Generation	Specialized	Video, Image	Text	Video, Image	High	<50	Online	No integration	Freemium, Subscription	Stored and Used for AP	Documentation	kaiber.ai
	37	Opus.pro	Video Generator	0,0224	Video and Audio Editing	Specialized	Video	Sound	Video	High	<50	Online	No integration	Subscription	Stored and Used for AP	Documentation, Video Tutorials	opus.pro

A		B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R
	No.	Tool Name	Category	Popularity (Total Visits bn)	Main Applications	Scope of Application	Input Data Type (Basic)	Input Data Type (Additional)	Output Data Type	User Control	Languages	Hardware Requirements	Integration with other tools	Pricing model and license	Privacy Management	Training Materials	Web Address
Sound oriented tools	38	Vocal Remover	Voice & Music	0,1655	Other Specialized (Sound Analysis, Vocal Removal)	Specialized	Sound	None	Sound	Low	1 (English)	Online	No integration	Free	Stored and Used for AP	Documentation	vocalremover.org
	39	ElevenLabs	Voice & Music	0,0886	Other Specialized (Voice Synthesis)	Specialized	Sound	None	Sound	High	<50	Online	No integration	Freemium, Pay-as-you-go	Stored and Used for AP	Documentation	elevenlabs.io
	40	Voicemod	Voice & Music	0,0735	Other Specialized (Voice Effects)	Specialized	Sound	None	Sound	Medium	1 (English)	Local (online)	No integration	Freemium, Subscription	Stored and Shared	Documentation, Video Tutorials	voicemod.net
	41	Otter.ai	Voice & Music	0,0707	Teaching and Education (Transcription Support)	Universal	Sound	Text	Text	Low	<50	Online	Compatibility	Freemium, Subscription (Educational)	Stored and Used for AP (with User Control)	Documentation, Video Tutorials	otter.ai
	42	Noty.ai	Voice & Music	0,009	Teaching and Education (Transcription Support)	Universal	Sound	Text	Text	Low	<50	Online	Compatibility	Freemium, Subscription	Stored and Used for AP	Documentation, Video Tutorials	noty.ai
Automation oriented tools	43	Hugging Face	Data Science	0,3166	Data Analysis and AI Models	Specialized	Text, Tabular Data	Complex	Tabular Data, Text	High	<10, Adaptable	Online / Local + (limited offline)	Flexible API, Compatibility	Free, Pay-as-you-go (Educational, Open-source)	Stored and Used for AP (with User Control)	Documentation, Online Courses, User Community	hugging-face.co
	44	Hotpot.ai	Design	0,1253	Image and Graphic Generation, Creative Applications	Specialized	Text, Image	None	Image	High	<50	Online	Compatibility	Freemium, Subscription	Stored and Used for AP	Documentation, Video Tutorials	hotpot.ai
	45	Tome	Design	0,0884	Creative Applications	Universal	Text	Image	Text, Image	Medium	<50	Online	No integration	Freemium, Subscription	Stored and Used for AP	Documentation, Video Tutorials	tome.app
	46	Eightfold AI	Recruiter	0,0772	Process Automation	Specialized	Tabular Data	Text	Tabular Data	Low	<50	Online	Compatibility	Subscription	Stored and Used for AP	Documentation, Video Tutorials	eightfold.ai
	47	Photo -Room	Design	0,0661	Background Removal and Image Modification	Specialized	Image	None	Image	Low	<50	Online	Compatibility	Freemium, Pay-as-you-go	Stored and Shared	Documentation, Interactive Materials	photo-room.com
	48	Zyro	Design	0,0601	Creative Applications	Universal	Text	Image	Text, Image	Medium	<50	Online	Compatibility	Subscription (Educational)	Stored and Shared	Documentation, Video Tutorials	zyro.com
	49	Gamma	Design	0,0276	Creative Applications	Universal	Text	Image	Text, Image	Medium	<50	Online	No integration	Freemium, Subscription	Stored and Used for AP	Documentation, Interactive Materials	gamma.app
	50	Taskade	Task Manager	0,0231	Process Automation	Universal	Text	None	Text	Medium	Multilingual	Online	Compatibility	Freemium, Subscription	Stored and Used for AP	Documentation, Video Tutorials	taskade.com

Table 1. Legend I: Characteristic aspects of AI tools (elaborated by B. Adamiczka)
Tabela 1. Legenda I: Aspekty charakteryzujące narzędzia AI (oprac. B. Adamiczka)

A	B	C
Name of the Characterizing Aspect	Definition / Description of the Characterizing Aspect	Set of Values
Main Applications	Defines the key areas where the AI tool finds practical application. It indicates the type of activities the tool supports and the fields in which it can be utilized.	Text generation – creating, editing, paraphrasing, and synthesizing texts.
		Conversations and chatbots – interactive dialogues and customer support, personal chatbots.
		Image and graphics generation – creating images from descriptions, generative art, graphic design.
		Video and audio editing – creating or editing multimedia content.
		Process automation – tools supporting business processes such as recruitment, task management.
		Data and AI model analysis – platforms supporting the building, testing, and deployment of AI models.
		Background removal and image modification – precise removal of image elements or editing details.
		Creative applications – generating artistic, literary, or visual content.
		Teaching and education – creating educational materials, language learning support, or generating interactive content.
		Other specialized – tools with unique functions, such as sound analysis or vocal removal from songs.
Scope of Application	Defines whether the tool has a wide application across various fields (universal) or is dedicated to specific tasks (specialized).	Universal – tools with a wide range of functions, enabling use across various fields and tasks without the need for specialized knowledge.
		Specialized – tools designed for specific applications or industries, focused on particular functions that require knowledge and have limited functions outside the target application.
Input Data Type (Basic)	Defines the basic type of data that the user inputs into the tool to obtain the expected results.	Text – written data, such as queries, paragraphs, or documents, processed for content generation or analysis.
		Image – graphic files, photos, or illustrations used for analysis, editing, or generation.
		Video – films or animations subjected to editing, analysis, or new content generation.
		Sound – audio recordings, music, or other sounds, transformed or analyzed.
		Tabular Data – structured data in tables, such as spreadsheets or CSV files, used for analysis or modeling.
		3D Model – spatial three-dimensional data used for rendering, analysis, or animation.
		Complex – data combining various formats, such as text, images, video, or sound, for multidimensional processing.
Input Data Type (Additional)	Defines the additional type of data that the user inputs into the tool to obtain the expected results (as attachments or additional, less frequently used data formats).	Text – written data, such as queries, paragraphs, or documents, processed for content generation or analysis.
		Image – graphic files, photos, or illustrations used for analysis, editing, or generation.
		Video – films or animations subjected to editing, analysis, or new content generation.
		Sound – audio recordings, music, or other sounds, transformed or analyzed.
		Tabular Data – structured data in tables, such as spreadsheets or CSV files, used for analysis or modeling.
		3D Model – spatial three-dimensional data used for rendering, analysis, or animation.
		Complex – data combining various formats, such as text, images, video, or sound, for multidimensional processing.

A	B	C
Name of the Characterizing Aspect	Definition / Description of the Characterizing Aspect	Set of Values
Output Data Type	Defines the type of results generated by the AI tool in response to the user's input data.	Text – written data, such as queries, paragraphs, or documents, processed for content generation or analysis.
		Image – graphic files, photos, or illustrations used for analysis, editing, or generation.
		Video – films or animations subjected to editing, analysis, or new content generation.
		Sound – audio recordings, music, or other sounds, transformed or analyzed.
		Tabular Data – structured data in tables, such as spreadsheets or CSV files, used for analysis or modeling.
		3D Model – spatial three-dimensional data used for rendering, analysis, or animation.
		Complex – data combining various formats, such as text, images, video, or sound, for multidimensional processing.
User Control	Defines the approximate degree to which the user can influence the result through personalization, parameter selection, or iterative refinement of outcomes.	Low – lack of or limited ability to adjust parameters or iteratively refine results.
		Medium – moderate control with customization options, such as tone, style, or detailed prompts.
		High – significant control over results with detailed parameters, editing tools, or iterative improvements.
Hardware Requirements	Defines whether the tool requires an internet connection, whether the software needs to be downloaded and installed on the user's device, and whether advanced hardware is required.	Online – the tool operates entirely in a web browser or through an online application; requires an internet connection; does not require advanced user hardware.
		Online+ – the tool operates entirely in a web browser or through an online application; requires an internet connection; requires advanced user hardware.
		Local (online) – the tool requires downloading and installing software on the user's device; requires an internet connection; does not require advanced user hardware.
		Local+ (online) – the tool requires downloading and installing software on the user's device; requires an internet connection; requires advanced user hardware.
		Local (limited offline) – the tool requires downloading and installing software on the user's device; does not require an internet connection; limited functionality without an internet connection; does not require advanced user hardware.
		Local+ (limited offline) – the tool requires downloading and installing software on the user's device; does not require an internet connection; limited functionality without an internet connection; requires advanced user hardware.
		Local (offline) – the tool requires downloading and installing software on the user's device; does not require an internet connection; full functionality without an internet connection; does not require advanced user hardware.
		Local+ (offline) – the tool requires downloading and installing software on the user's device; does not require an internet connection; full functionality without an internet connection; requires advanced user hardware.
Languages	Defines the range of languages supported by the tool, including multilingual capabilities and the ability to adapt to specific languages.	1 – the tool supports only one language.
		<10 – the tool supports between 2 and 10 languages, offering limited multilingual support.
		<50 – the tool supports between 11 and 49 languages, providing support for different regions and basic multilingual functionality.
		Multilingual – the tool supports over 50 languages, ensuring broad global availability.
		Adaptable – the tool allows for adding support for new languages through model training or introducing new data.

Table 1. Legend I continued: Characteristic aspects of AI tools (elaborated by B. Adamiczka)
Tabela1 Legenda I cd.: Aspekty charakteryzujące narzędzia AI (oprac. B. Adamiczka)

A	B	C
Name of the Characterizing Aspect	Definition / Description of the Characterizing Aspect	Set of Values
Pricing model and license	Defines the type of access to the tool, including its cost (with reference to educational licenses) and the nature of the license (with reference to open-source licenses).	Free – the tool is fully accessible without charges for the end user.
		Freemium – basic features of the tool are available for free, but advanced features require payment.
		Paid: One-time payment – requires a one-time license purchase, granting permanent access to features without further fees.
		Paid: Subscription – the user must regularly pay a fee (e.g., monthly, annually) for access to features.
		Paid: Pay-as-you-go – the user pays for each unit of use (e.g., processed data, generated content, or minutes).
Integration with other tools	Defines the ability to collaborate with other systems and the availability of an API interface, enabling integration with external applications.	No integration – the tool operates in isolation, with no integration capabilities with other platforms.
		Compatibility – the tool works with other popular systems or platforms (ready-to-use integrations for non-technical users with commonly used platforms).
		API flexibility – the tool offers a flexible API interface for easy integration with external applications (deep, flexible, and customizable integration for developers).
Training Materials	Defines the type and scope of available basic educational materials that support the user in learning how to use the tool.	Documentation – official documents describing features, user manuals, and technical specifications.
		Video tutorials – a set of video materials demonstrating how to use the tool.
		Online courses – comprehensive educational courses conducted on dedicated platforms or within the tool itself.
		Webinars – online meetings conducted by experts to familiarize users with the tool's features or methods of use.
		User community – forums, discussion groups, or communities supporting the exchange of knowledge and experiences.
		Interactive materials – exercises, simulations, or interactive tutorials available within the tool.
		No materials – no available educational materials.
Privacy Management	Defines how the tool manages user data, including storage, sharing, and privacy protection (with user control included).	Stored and shared – user data is stored and may be shared with third parties.
		Stored and used for AP – data is stored and used for analysis but not shared.
		Not stored – data is not stored after the user session ends.

Table 1. Legend II: Areas of application of AI tools with indication of characteristic application possibilities in the use of inventive methods (elaborated by B. Adamiczka)
Tabela1 Legenda II: Obszary zastosowania narzędzi AI ze wskazaniem charakterystycznych możliwości ich zastosowania w toku wykorzystania metod inwentycznych (oprac. B. Adamiczka)

A	B	C	D	E	F	G
No.	Application Area	Description	Main Applications	Examples of AI tools	Number of tools	Characteristic application possibilities in the use of inventive methods
1	Text oriented tools	Tools supporting natural communication in the form of conversations and text generation, ranging from short responses to complex creative and functional content. Used in chatbots, voice assistants, marketing, and writing.	Conversations and Chatbots, Text Generation, Creative Applications	ChatGPT, Character AI, Quillbot, Google Bard, NovelAI, Janitor AI, You.com, Perplexity AI, Copy.ai, Jasper, Writesonic, CrushOn AI, Claude AI, Personal AI, ChatDoc	15	Generating concept lists, paraphrasing and transforming text, creating metaphors and analogies, analyzing and synthesizing information, iterative refinement, supporting the narrative process, automatic question generation.
2	Image oriented tools	Tools for generating, editing, and modifying images, including background removal and graphic enhancement. Useful in design, digital art, and visual marketing.	Image and Graphic Generation, Background Removal and Image Modification	MidJourney, CivitAI, Cutout.pro, Craiyon, Leonardo AI, DeepAI, Playground AI, Stable Diffusion Web, Clipdrop, Lexica.art, PixAI, OpenArt, ZMO.AI, Remini, Dezgo, VanceAI	16	Text to image transformation, creating variations and transformations of images, combining multiple images or fragments, simulating effects and styles, removing or editing selected elements.
3	Automation oriented tools	Tools that combine creativity with process automation, supporting the creation of presentations, visual materials, and task and data management. They enhance the efficiency of both creative and operational work.	Creative Applications, Image and Graphic Generation, Data Analysis and AI Models, Process Automation, Other Specialized (Recruitment, Task Management)	Hugging Face, Hotpot.ai, Tome, Eightfold AI, PhotoRoom, Zyro, Gamma, Taskade	8	Automatic generation of proposal lists, streamlining data analysis, automatic prototyping and iteration, automation of repetitive tasks, creating graphical representations of data sets, optimization of evaluation processes.
4	Video oriented tools	Tools for video and audio editing, creating multimedia content, and supporting creative projects in education and marketing. They facilitate the production of professional audiovisual materials.	Video and Audio Editing, Creative Applications, Teaching and Education	CapCut, Runway ML, D-ID, Synthesia, Kaiber, Opus.pro	6	Transforming text into animation, animating still images, combining and mixing multiple materials or segments, simulating effects and styles, automating clip and narration editing.
5	Sound oriented tools	Tools specialized in sound processing, voice synthesis, music analysis, and speech transcription. They are used in education, music production, and sound effect creation.	Other Specialized (sound analysis, vocal removal, voice synthesis), Teaching and Education (transcription support)	Vocal Remover, ElevenLabs, Voicemod, Otter.ai, Noty.ai	5	Generating new sounds and effects, transforming and modifying sounds, removing and isolating elements, creating synthesized voices, automatic transcription.

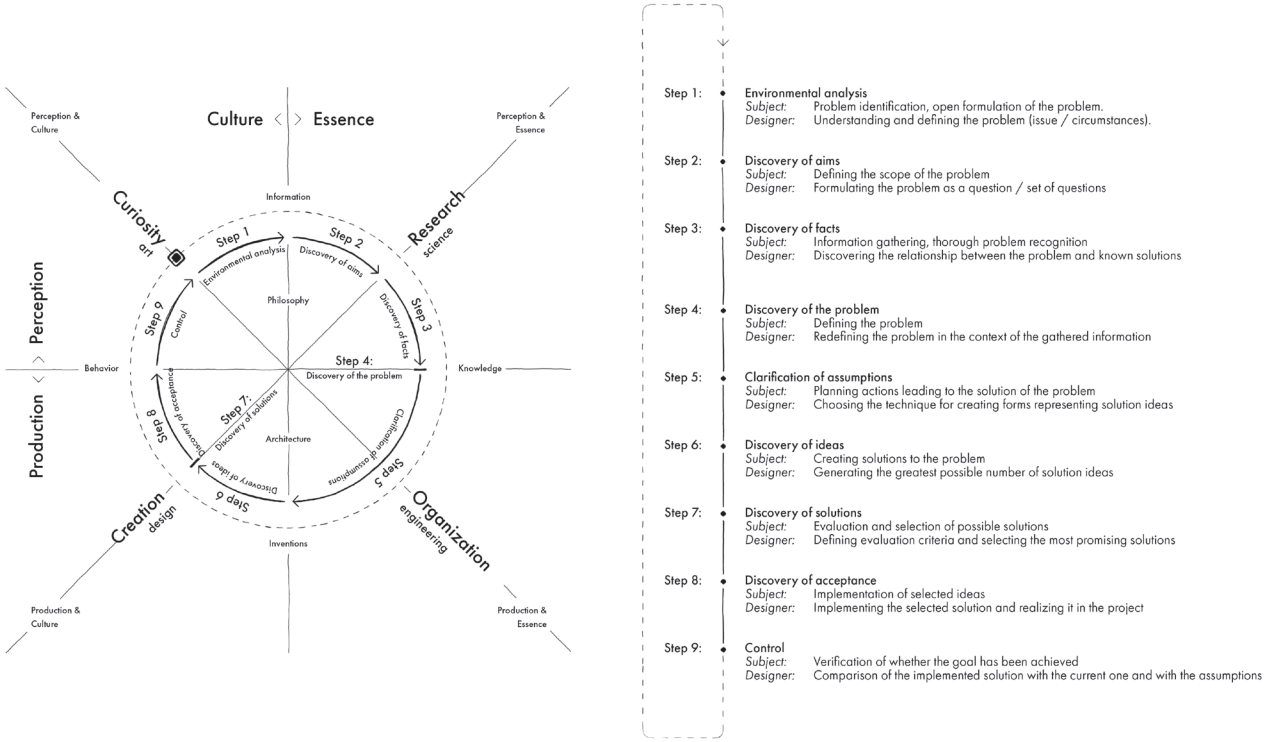

Fig. 2. Diagram and steps of the creative problem-solving process path model as a strategy for architectural form design
(source: Adamiczka 2022, 109)

Il. 2. Diagram i kroki modelu ścieżki procesu twórczego rozwiązywania problemów jako strategii projektowania formy architektonicznej
(źródło: Adamiczka 2022, 109)

approach enables not only a faster selection of the appropriate tool but also better alignment with individual design requirements.

The classification of tools into five main application areas enables easier identification and selection of the appropriate tool for a given task without the need to analyse each tool individually. These areas also highlight the characteristic possibilities of applying AI tools from each group within the context of using inventive methods. At the same time, similar to inventive methods, these tools are not strictly tied to architecture, indicating the need for an interdisciplinary approach to their use – not as problem-solving tools but rather as instruments that support the process of creative problem-solving.

It should be noted that the developed system allows for adjusting the selection of AI tools to the creator's preferences regarding their functionality and characteristics. Furthermore, it also enables decision-making based on the stage of the creative problem-solving process and the specific inventive method, which is related to the work with the sought-after AI tool.

Summary

The study provides new insights into applying AI tools in the creative problem-solving process, particularly in the context of inventive methods. Through the conducted research, a tool enabling the practical use of AI in architectural design has been developed. An open classification system for AI tools was established based on their availability, popularity, and intuitiveness. This fills a gap in the existing literature, offering a tool that allows for comparing and selecting AI solutions that support designers at various stages of the creative process. Five application areas for AI tools were defined, significantly simplifying their identification and matching to specific tasks. This approach eliminates the need for a detailed analysis of each tool individually. The classification by application areas and their parameterization allows for quick comparison and selection of the most suitable solutions, while the developed tabular summaries facilitate decision-making. As a result, all the set goals were achieved, creating an AI tool system tailored to the preferences of creators, considering the context of the stages of the creative problem-solving process and inventive methods.

The study focused on widely available and intuitive tools, excluding more advanced, specialized solutions. The direct effectiveness of the tools was not assessed, nor was there any indication of direct integration with specific inventive methods, leaving room for further verification of their practical application. The dynamic development of AI means that the list of tools will require regular updates.

The results of the study and research limitations indicate the need for further verification of the possibilities and effectiveness of integrating AI tools with inventive methods, including within practical design applications.

Table 2. Possibilities of using AI tools in the context of the steps in the model path of the creative problem-solving process (elaborated by B. Adamiczka)
Tabela 2. Możliwości wykorzystania narzędzi AI w kontekście kroków modelu ścieżki procesu twórczego rozwiązywania problemów (oprac. B. Adamiczka)

A	B	C	D
Step of the creative problem-solving model path	The subject of the step and the role of the designer	Application Area	Indicating example use cases at different stages of the process
Step 1: Environmental analysis	Subject: Problem identification, open formulation of the problem. Designer: Understanding and defining the problem (issue / circumstances).	Text oriented tools	Generating initial definitions of the problem, creating questions supporting analysis, transforming collected data into understandable text or reports.
		Image oriented tools	Visualizing the problem environment, creating mind maps, generating images representing the issue.
		Video oriented tools	Creating dynamic visualizations of the problem or scenarios, documenting the problem environment using edited video recordings.
		Sound oriented tools	Recording or sound analysis related to the context of the problem.
		Automation oriented tools	Automating the collection and analysis of environmental data, generating data visualizations and process maps.
Step 2: Discovery of aims	Subject: Defining the scope of the problem Designer: Formulating the problem as a question / set of questions	Text oriented tools	Generating creative questions supporting problem exploration, creating open-ended queries.
		Image oriented tools	Creating visual representations of questions or challenges, which helps in better understanding them.
		Video oriented tools	Generating a video presenting questions in the context of the problem, visualizing challenges in a narrative way.
		Sound oriented tools	Simulating challenges in an auditory form.
		Automation oriented tools	Automatically organizing questions in the form of presentations or diagrams, organizing conclusions gathered in step 1.
Step 3: Discovery of facts	Subject: Information gathering, thorough problem recognition Designer: Discovering the relationship between the problem and known solutions	Text oriented tools	Creating timelines based on textual data, generating summaries of complex information, historical analysis, and forecasting the future.
		Image oriented tools	Generating diagrams, charts, and historical maps presenting data in an visually appealing format.
		Video oriented tools	Creating dynamic timeline visualizations, presenting trends in a video format.
		Sound oriented tools	Analyzing audio data on a timeline, identifying trends in the acoustic environment.
		Automation oriented tools	Automated analysis of historical data, visualizing trends and their relationships over time, identifying key moments.
Step 4: Discovery of the problem	Subject: Defining the problem Designer: Redefining the problem in the context of the gathered information	Text oriented tools	Creating a new problem definition based on data analysis, paraphrasing, and refining formulations.
		Image oriented tools	Updating visual representations of the problem based on the collected information.
		Video oriented tools	Creating video presentations of the new problem definition based on the collected information.
		Sound oriented tools	Adding narration or sound effects to the redefined problem, helping to illustrate changes in the acoustic environment.
		Automation oriented tools	Generating reports that redefine the problem, visualizing data updated based on new information.
Step 5: Clarification of assumptions	Subject: Planning actions leading to the solution of the problem Designer: Choosing the technique for creating forms representing solution ideas	Text oriented tools	Generating lists of tools and techniques, organizing work schedules.
		Image oriented tools	Creating graphical cheat sheets and visual instructions.
		Video oriented tools	Preparing video tutorials supporting the use of techniques and tools.
		Sound oriented tools	Recording audio instructions and guidelines.
		Automation oriented tools	Automating schedule creation, organizing work based on established priorities.

Table 1 continued. Possibilities of using AI tools in the context of the steps in the model path of the creative problem-solving process (elaborated by B. Adamiczka)
Tabela 2 cd. Możliwości wykorzystania narzędzi AI w kontekście kroków modelu ścieżki procesu twórczego rozwiązywania problemów (oprac. B. Adamiczka)

A	B	C	D
Step of the creative problem-solving model path	The subject of the step and the role of the designer	Application Area	Indicating example use cases at different stages of the process
Step 6: Discovery of ideas	Subject: Creating solutions to the problem Designer: Generating the greatest possible number of solution ideas	Text oriented tools	Generating textual descriptions of ideas and expanding their forms.
		Image oriented tools	Creating visual forms of ideas and their transformations.
		Video oriented tools	Generating prototype video visualizations presenting the concepts of ideas.
		Sound oriented tools	Creating audio interpretations of ideas, e.g., sound effects illustrating different concepts.
		Automation oriented tools	Automatic sorting and organization of work results.
Step 7: Discovery of solutions	Subject: Evaluation and selection of possible solutions Designer: Defining evaluation criteria and selecting the most promising solutions	Text oriented tools	Assistance in formulating evaluation criteria, organizing results of idea assessments.
		Image oriented tools	Visualization of evaluation results, e.g., in the form of tables or charts.
		Video oriented tools	Preparing video presentations comparing different ideas and their assessments.
		Sound oriented tools	Adding audio explanations or opinions to the evaluation results.
		Automation oriented tools	Automatic processing of evaluation results and generating summary reports.
Step 8: Discovery of acceptance	Subject: Implementation of selected ideas Designer: Implementing the selected solution and realizing it in the project	Text oriented tools	Creating implementation reports, contextual analyses; documenting changes and adapting the implemented solution to the project conditions.
		Image oriented tools	Creating prototype graphics, visualizing changes and integrating new concepts with the existing project environment.
		Video oriented tools	Creating video presentations of prototypes, generating animations or videos showing how the implemented solution functions in practice.
		Sound oriented tools	Implementation narration and audio presentation.
		Automation oriented tools	Organizing team work, managing tasks, and monitoring progress.
Step 9: Control	Subject: Verification of whether the goal has been achieved Designer: Comparison of the implemented solution with the current one and with the assumptions	Text oriented tools	Creating text-based comparisons of implemented solutions with initial assumptions.
		Image oriented tools	Creating comparative graphics of „before and after”, showing the differences between the implementation and the initial assumptions.
		Video oriented tools	Preparing video materials comparing the effects of the implementation with earlier visions and project concepts.
		Sound oriented tools	Recording audio summaries of the project, creating narrative reports in the form of podcasts or recordings.
		Automation oriented tools	Generating reports and outcome summaries, comparing them with the assumptions, which streamlines the analysis of the effectiveness of the implementation.

An important aspect is also their inclusion in architectural education, which will enable future designers to effectively and consciously use AI tools in the creative process.

The developed systematics supports designers by facilitating the conscious selection and choice of AI tools – both according to their preferences and in the context of the stages of the creative problem-solving process and the nature of the methods being used. The study opens new perspectives for architects and creators, enabling the implementation of innovative technologies in the creative process to support creativity rather than a replacement.

Translated by
Bartosz Adamiczka

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Streszczenie

Systematyka narzędzi AI wspierających twórcze rozwiązywanie problemów i metody inwentyczne w projektowaniu architektonicznym

Dynamiczny rozwój narzędzi opartych na sztucznej inteligencji (AI) istotnie wpływa na współczesne procesy projektowe, w tym projektowanie architektoniczne. Narzędzia te otwierają nowe perspektywy dla twórców, wspierając ich na różnych etapach pracy. AI w architekturze staje się kluczowym elementem wspomagającym projektantów w rozwiązywaniu problemów, jednak nadal brakuje systematycznego ujęcia i klasyfikacji związanych z nią narzędzi pod kątem twórczego rozwiązywania problemów, metod inwentycznych oraz podejścia intuicyjnego i myślenia metaforycznego, które jest istotne w procesie kreacji.

Tematem artykułu są możliwości zastosowania powszechnie dostępnych narzędzi sztucznej inteligencji jako wsparcia metod inwentycznych w procesie twórczego rozwiązywania problemów. Pierwszym celem autora jest usystematyzowanie narzędzi AI pod kątem ich potencjalnych zastosowań w kontekście metod inwentycznych. Drugim – identyfikacja sposobów wykorzystania tych narzędzi na poszczególnych etapach twórczego rozwiązywania problemów.

Analiza została oparta na danych pozyskanych metodą desk research oraz klasyfikacji narzędzi według kryteriów popularności i funkcjonalności. W ramach badania narzędzia pogrupowano w pięć obszarów zastosowań, odnosząc je do kolejnych etapów procesu twórczego rozwiązywania problemów.

W toku badań zastosowano metody analizy literatury, obserwacji, dedukcji i syntezy, co pozwoliło na kompleksową weryfikację pozyskanych danych. Dodatkowo, proces badawczy oparto na metodach inwentycznych, takich jak: analiza literatury przedmiotu, szukanie związków, odpowiedniość między teoriami, wycieczka przykładowa, mapy myślowe oraz dedukcja – poprzedzonych metodą intuicyjną, która stanowiła impuls dla działań koncepcyjnych na każdym etapie badań.

Wynikiem pracy jest otwarta systematyka narzędzi AI umożliwiająca projektantom porównanie i wybór narzędzi najlepiej odpowiadających ich potrzebom i preferencjom. Klasyfikacja narzędzi według obszarów zastosowań umożliwia wybór narzędzia ze względu na charakter wykorzystywanych metod inwentycznych oraz etap procesu twórczego rozwiązywania problemów. Opracowane zestawienia tabelaryczne pozwalają na świadomą i prostą identyfikację narzędzi odpowiednich do poszczególnych zadań. Wyniki badań wskazują na potrzebę dalszej weryfikacji praktycznego zastosowania narzędzi AI oraz ich uwzględnienia w edukacji architektonicznej, co pozwoli na pełniejsze wykorzystanie potencjału tych technologii w procesie projektowym.

Słowa kluczowe: projektowanie architektoniczne, AI, metody inwentyczne, twórcze rozwiązywanie problemów